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TITLE OPERATIONAL EVALUATION OF THE HIGH FLOW ALTERNATIVE FILTER TEST SYSTEM

AUTHOR(S) R. C. Scripsick, R. L. Smitherman, and S. A. McNabb

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Los Alamos
Los Alamos National Laboratory
Los Alamos, New Mexico 87545

OPERATIONAL EVALUATION OF THE HIGH FLOW ALTERNATIVE FILTER TEST SYSTEM*

Ronald C. Scripsick, Roy L. Smitherman,[1] and Sam A. McNabb[1]

Los Alamos National Laboratory
Research and Development Section
Industrial Hygiene Group
Health, Safety, and Environment Division
Los Alamos, NM 87545
USA
[1]Oak Ridge Gaseous Diffusion Plant
Martin Marietta Energy Systems, Inc.
P. O. Box P
Oak Ridge, TN 37830
USA

Abstract

An alternative to the current filter test system (Q107) used to test Size 4 (500 cubic feet per min rated flow) and larger nuclear grade high efficiency particulate air (HEPA) filters at DOE Filter Test Facilities (FTFs) has been developed. This new test system, called the High Flow Alternative Filter Test System (HFATS), has undergone a long-term operational evaluation at the Oak Ridge FTF (ORFTF) for: 1) comparison between HEPA filter penetration measurements made with the HFATS and with the Q107; 2) assessment of the HFATS' long-term routine operational performance in the FTF environment; and 3) determination of the potential operational impacts of the HFATS on the FTFs.

Data for the operational evaluation were collected by the Oak Ridge staff using both test systems. These data were analyzed and interpreted by Los Alamos staff. A total of 849 filters were tested in the evaluation. The data provided by the HFATS easily permits filter penetration to be reported in terms of: 1) penetration at the size of maximum penetration; 2) number, surface area, or mass penetration; or 3) penetration at 0.3 µm for reference to historical data. Results of the penetration measurement comparisons show that the HFATS measurements at approximately 0.3 µm aerosol diameter do not differ significantly from the Q107 measurements. Analysis of the HFATS penetration data indicates that for the 100% flow tests maximum penetration most frequently occurs at an aerosol diameter of approximately 0.15 µm as measured by a laser aerosol spectrometer (LAS). The 0.15 µm HFATS measurements at 100% test flow were markedly higher than the corresponding Q107 measurements. These measurements resulted in over 18% of the filters being rejected by the HFATS only, compared to no filters being rejected only by the Q107 and approximately 0.2% being rejected by both systems.

* Work performed at Los Alamos National Laboratory under the auspices of the U. S. Department of Energy, Interim Waste Operations, Contract No. W-7405-ENG-36.

Investigation of how the HFATS performed over the course of the study included monitoring of the HFATS diluter performance, the LAS size calibration, and the upstream count rate. The upstream count rate is a sensitive indicator of changes in the output of the blower and the HFATS aerosol generator as well as in the performance of the HFATS diluter and the LAS. Analysis of the monitoring results indicates that the HFATS performed at or above acceptable performance limits.

Review of information collected on the operational impact the HFATS had on the FTF indicates that: 1) there is no difference in the number of filters tested in a day by the two systems; 2) the HFATS presents certain operational safety advantages over the Q107; 3) the HFATS is easier to operate than the Q107; and 4) the HFATS may require less maintenance than the Q107.

The overall conclusion of the operational evaluation is that the HFATS is capable of performing well in the FTF environment and that the HFATS offers some important operational advantages relative to the Q107. Given the results of this study and a technical evaluation of the HFATS reported elsewhere the authors recommend that the DOE consider adoption of the HFATS as an approved filter test method.

I. INTRODUCTION

From FY 1981 and continuing through FY 1985, the Airborne Waste Management Program Office funded the "Filter Test Facility Support Laboratory," (FTFSL) project at Los Alamos to: 1) develop an aerosol test system suitable for use at the three Filter Test Facilities (FTFs) as a potential replacement for the current di(2-ethylhexyl) phthalate (DEHP, also known as DOP) test system (Q107) used to test size 4 and greater nuclear grade high efficiency particulate air (HEPA) filters and 2) provide technical assistance to the FTFs in solving technical problems and answering technical questions which arose. Completion of the FTFSL project provided recommendations for changes in the test systems used at the FTFs. One major recommendation of the FTFSL program was to perform a long-term operational evaluation of the high flow alternative filter test system (HFATS) which was developed in the program.

In late FY 1985 such a long-term study funded by DOE-Interim Waste Operations (IWO) was initiated at the Oak Ridge FTF (ORFTF) as a cooperative effort between the ORFTF and Los Alamos. The overall objective of the long-term study was to provide data necessary to qualify the HFATS as a DOE approved test method under the provisions of the Nuclear Standard NE-F-3-43, which require evidence that new test systems are capable of being "operated and maintained" by FTF operators.(1) In order to accomplish this overall objective certain subordinate objectives were identified. These subordinate objectives include:

1. Comparison of HEPA filter penetration measurements made with the HFATS and the Q107 including assessment of the potential impacts the HFATS measurements may have on the FTF filter rejection rates.

2. Assessment of the HFATS's long-term, routine performance in the FTF environment.

3. Determination of the potential impacts of the HFATS on the FTF's operation.

The data collection phase of the study began August 15, 1985, and was completed by the end of May 8, 1986. This report presents the results of the study.

Description of Alternative Test System

The HFATS, which is shown diagrammatically in Figure 1, uses a modified Laskin nozzle aerosol generator to provide the filter challenge.(2) This aerosol generation system is easier to operate than the Q107 thermal generator, operates well below the flash point of DEHP, and is expected to produce no decomposition materials. This unit is also less expensive to manufacture than the thermal generator.

A laser aerosol spectrometer (LAS, Model LAS-X-M, Particle Measuring Systems, Inc., Boulder, Colorado) interfaced with a microcomputer (Model HP-85B, Hewlett-Packard Co., Corvallis, Oregon) and a Los Alamos fabricated aerosol diluter are used to perform the required aerosol measurements in the HFATS. This monitoring system combines the function of the Owl and the scattered-light photometer

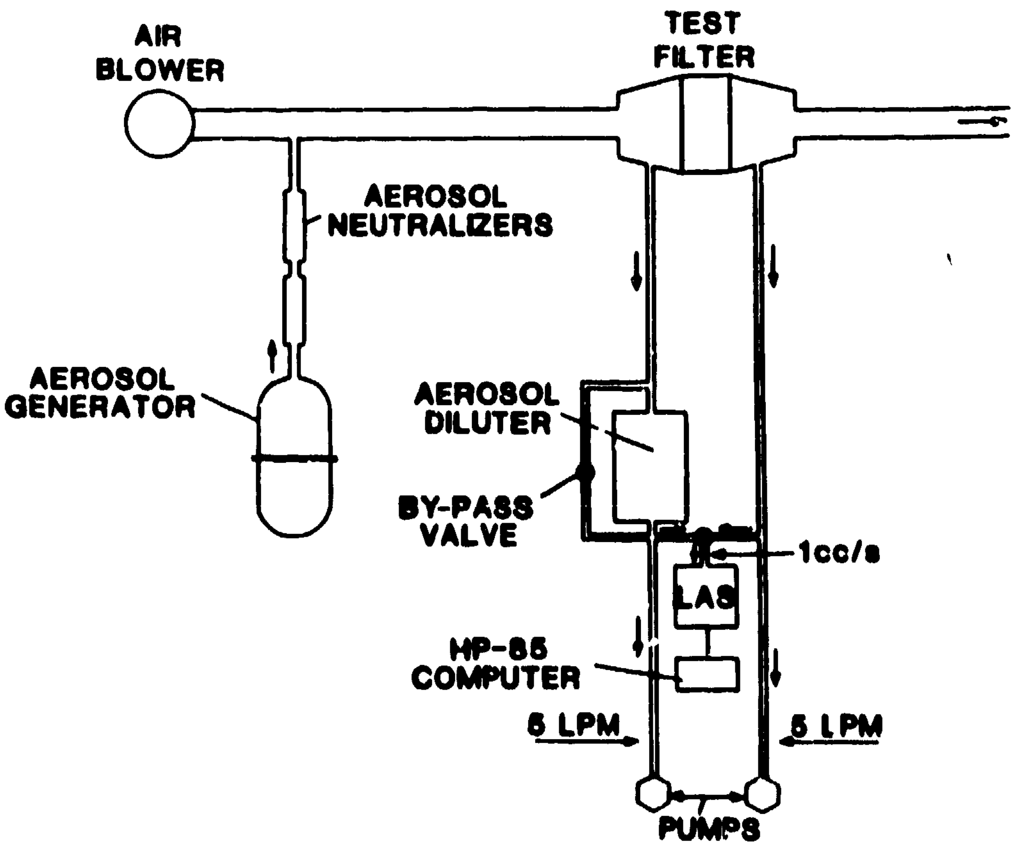

Figure 1. A diagram of the High Flow Alternative Filter Test System.

in the Q107 system. The monitoring system is capable of measuring penetration at a specific size or over a range of sizes in the aerosol diameter range from ~0.1 µm to ~0.4 µm.[2]

II. EQUIPMENT AND PROCEDURES

The operational evaluation was a long-term evaluation of the HFATS under routine operating conditions at a DOE FTF. The general study plan called for collection of penetration data at the ORFTF on a set of filters using both the HFATS and the Q107. Simultaneously, data detailing the performance and impacts of the HFATS were collected. The term of the data collection was approximately 9 months.

The HFATS was modified and installed at the ORFTF by Los Alamos staff prior to the start of the data collection. Modification of the HFATS was necessary to assure easy operation of the system when it was adapted to the ORFTF Q107. The major modification was to mount the HFATS aerosol sample transport valves, the HFATS diluter. the LAS and the HP-85 microcomputer so that they were within arm's reach of the Q107's work station. The HFATS aerosol generator system was installed between the Q107 blower and the Q107 thermal generator. Installation of the HFATS also involved performing a series of tests to insure proper operation. Installation and performance testing required approximately 4 working days.

The operational evaluation data collection entailed making filter penetration measurements using both the Q107 system and the HFATS, collection of data on HFATS performance, and collection of data on the impact of the HFATS on the FTF operation. The procedures for conducting the study at the FTF were modeled after those used in the One-Year LAS Comparison Study.[3,4] Los Alamos staff trained the FTF staff in the operation of the HFATS and the procedures to be used in collecting and recording data. The training required approximately 3 working days. All data collection and recording was performed by ORFTF staff.

The penetration data collected in the study provided information on penetration measurements made using the HFATS relative to those made using the Q107 under existing standard operating procedures. Penetration measurements on a group of filters were made first with the HFATS and then with the Q107 system. This measurement order insured final integrity of the FTF quality assurance (QA) measurements by precluding any out-of-the-ordinary handling of the filters subsequent to QA testing.

The HFATS penetration measurements were made in 15 size intervals (bins) over the aerosol diameter range from ~0.1 µm to ~0.4 µm with the LAS size measurement corrected for DEHP index of refraction.[5] These penetration values were automatically stored on cassette tape by the HP-85. The HFATS-measured penetration at the 0.31 µm diameter LAS bin was printed separately by the HP-85 and recorded manually by the system operator because 0.3 µm diameter is the traditional reference size for Q107 measurements. The penetration data stored on cassette tape permitted examination of penetration versus aerosol size.

A total of 849 filters were tested using both systems during the operational evaluation. A list of the sizes of filters tested is given in Table I. The "A" designation after a filter size indicates that filters in this category were tested at a flow above their rated-flow. Size "4A" filters were size "4" filters (500 cubic feet per min [CFM] rated-flow) that were tested at 600 CFM. Size "5A" filters were size "5" filters (1000 CFM rated-flow) that were tested at between 1170 CFM and 1400 CFM. Over 85% of the filters tested were size 5 filters.

In addition to penetration measurements, values of certain operational parameters for both test systems were recorded. The test system operator was required to manually record the filter serial number, the test airflow, and filter airflow resistance for the HFATS penetration measurements. The upstream particle count rate was automatically recorded by the HP-85 microcomputer for every filter test. This parameter is sensitive to changes in the output of the blower and the HFATS aerosol generator as well as to changes in the performance of the HFATS diluter and LAS. In addition, this parameter is printed by the HP-85 at the beginning of each filter test as an indication to the system operator as to how the HFATS is performing. At the beginning, of each filter test session the aerosol size calibration of the LAS was checked using monodisperse polystyrene microspheres. These data were automatically recorded by the HP-85 microcomputer. Information from the Q107 test system measurements that were required for the study was obtained from the FTF "Filter Inspection Reports."

The FTF staff kept track of the HFATS impacts/costs in terms of manpower, supplies, parts, operational difficulties, and maintenance/repair service. They noted any Q107 equipment or

TABLE I

FILTER SIZES TESTED

SIZE	NUMBER TESTED	RATED FLOW -CFM	100% TEST FLOW -CFM
4A*	21	500	600
5	737	1000	1000
5A*	39	1000	1170-1400
6	52	1250	1250

* The "A" indicates that filters were tested at flows greater than their rated-flows.

operating procedure changes or problems. The total time required to analyze a group of filters by each penetration measurement technique was recorded by the FTF staff.

Data recorded by the FTF staff were entered on a standard logsheet that was provided by Los Alamos. An example of this logsheet is shown in Figure 2. Data in the form of HP-85 data tapes and copies of logsheets were forwarded to Los Alamos on roughly a monthly basis. Los Alamos reviewed these data to insure that useful data were being collected.

LOG PAGE
COMPARISON STUDY OF THE ALTERNATIVE FILTER TEST SYSTEM
Conducted at OR FTF - FY1985/FY1986

DATE(S):____________________ SYSTEM USED:__________________

PURCHASE ORDER NO.:__________________
NUMBER OF FILTERS TESTED:
Item No. __________ thru Item No. __________
Total number tested: __________
TIME - Number of man-hours for executing:
Normal routines and procedures -__________
Non-routine procedures -__________
COST - (Dollar value of requisitions signed on above date): __________

REMARKS : USE AS MUCH SPACE AS NECESSARY
(eg. equipment breakdown, problems with operation of the ATS or Q 107, or other occurrences that could affect the data being collected)

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______________________ Operator's Initials: __________

CONTACT: Ron Scripsick, Aerosol Science Section
Los Alamos National Laboratory
Los Alamos, NM 87544 (505) 667-7382
FTS 843-7382

Figure 2. Example of standard logsheet used in the operational evaluation.

III. RESULTS AND DISCUSSION

COMPARISON OF PENETRATION MEASUREMENTS

HFATS Penetration Measurements

Typical HFATS penetration curves are illustrated in Figure 3. The 100% flow tests were characterized by a penetration maximum occurring at an aerosol diameter <0.2 µm which is in agreement with theoretical evaluations of modern nuclear grade HEPA filter media, experimental measurements made on flat sheets of nuclear grade HEPA filter media and experimental measurements made on constructed nuclear grade HEPA filters operated at 100% of rated flow.[6,7,8] The 20% flow tests did not display a maximum penetration within the aerosol size range studied (see Figure 3) which is contrary to theoretical predictions and measurements on flat sheet media.[6,7] Review of the literature revealed no independent penetration measurements of constructed nuclear grade HEPA filters operated at 20% of rated flow. Evaluation of the performance of the HFATS components gave no evidence that this characteristic might be an artifact of HFATS measurements. One possible explanation for this phenomenon is the presence of pinholes in the constructed filters.[2] Further investigation is necessary to explain this penetration behavior of HEPA filters operated at 20% flow.

Penetration Comparison with the 0.31 µm HFATS Data

Recent theoretical investigations that account for the Q107 challenge being polydisperse with a count geometric mean diameter between 0.14 µm to 0.18 µm suggest because of the photometer response bias towards larger particles that the Q107 penetration measurements

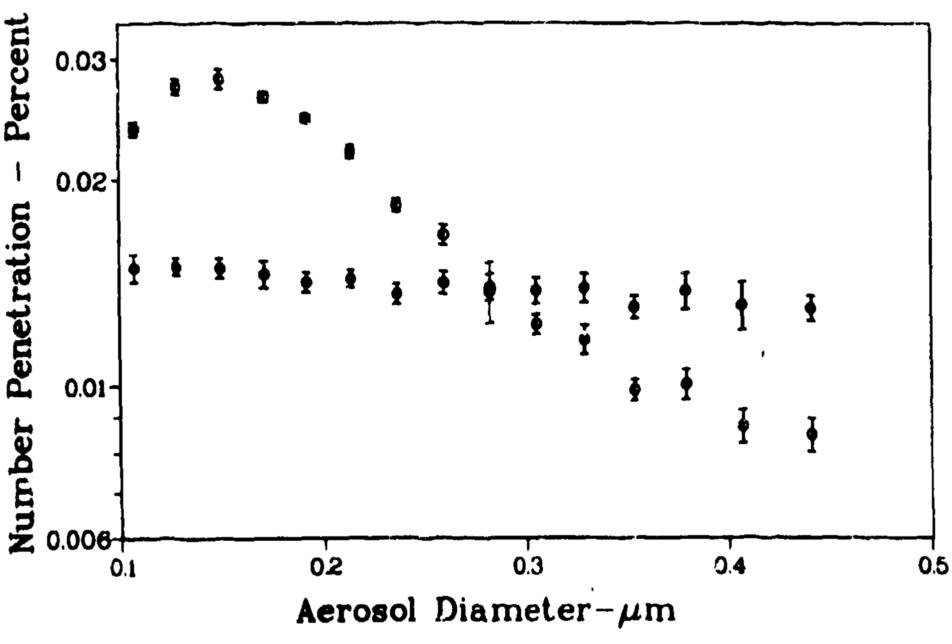

Figure 3. An example of the typical HFATS penetration curves obtained in the study. The 100% flow test data are indicated by the open circle data points and the 20% flow test data are represented by the closed circle data points.

are approximately equal to the penetration at 0.3 µm.[3,4 & 8] Because of this finding and the fact that the Q107 measurements have traditionally been referenced to 0.3 µm, the HFATS penetration measurements at the 0.31 µm bin diameter were compared with the Q107 measurements. This LAS bin was found to be approximately equal to 0.3 µm diameter as measured by the electrostatic classifier (Model 3071, TSI Incorporated, St. Paul, Minnesota).[2]

The results of the 0.31 um comparison for the 100% flow tests are shown in Figure 4 and for the 20% tests are shown in Figure 5. The results are similar for both flow tests. Also, no obvious difference was observed for the different sizes of filters. Average differences in penetration are listed in Table II. For both test flows the magnitude of the differences is $\leq$0.002%.

The number of filter tests where penetration measurements were above the penetration rejection limit of 0.03% (which to two significant digits is 0.035%) are listed in Table III. A total of seven filter tests resulted in both systems measuring penetrations above the rejection limit. The HFATS measured penetrations above the rejection limit in three situations where the Q107 measured penetrations were below the limit. In only one situation did the Q107 measure a penetration above the rejection limit where the HFATS measured penetration was below the limit.

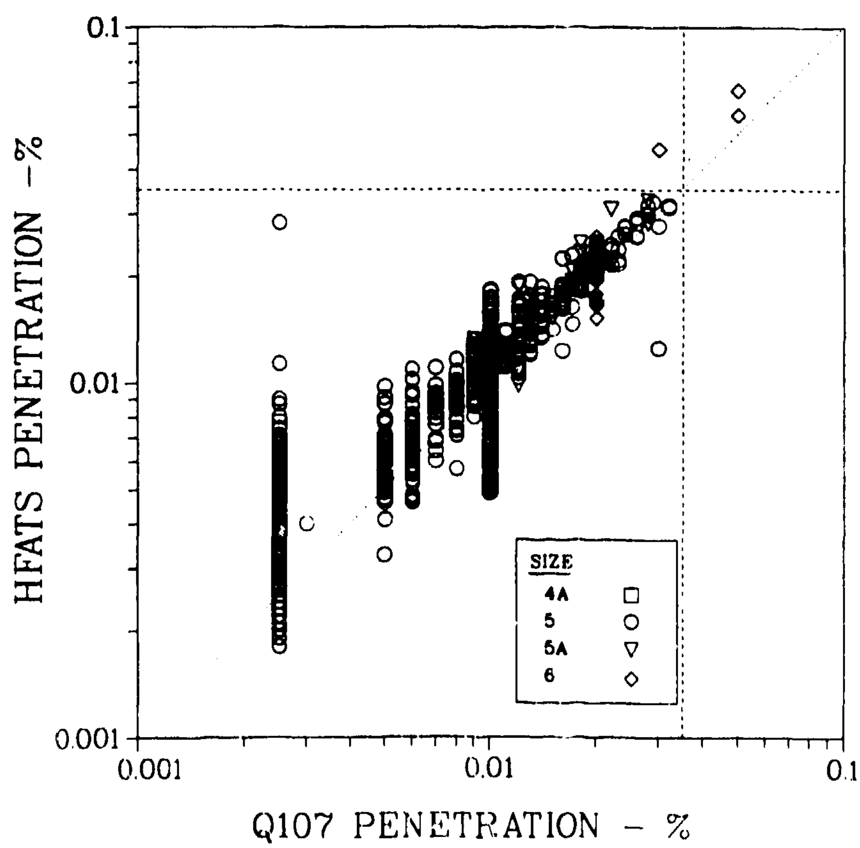

Figure 4. Comparison of the 100% flow test penetration measurements using the 0.31 µm HFATS data.

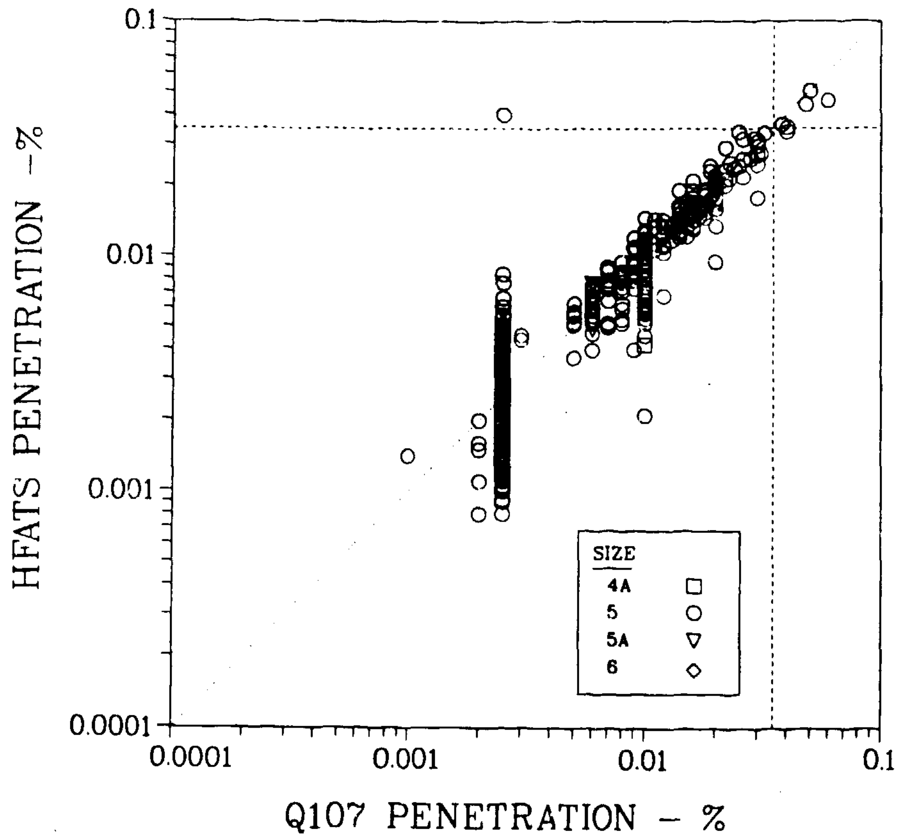

Figure 5. Comparison of the 20% flow test penetration measurements using the 0.31 µm HFATS data.

TABLE II

PENETRATION DIFFERENCES - 0.31 µm TESTS (HFATS - Q107)

FILTER SIZE	AVERAGE DIFFERENCE 100% FLOW	AVERAGE DIFFERENCE 20% FLOW
4A	-0.002*	-0.0004
5	0.001	-0.0004
5A	0.002	0.0002
6	0.002	0.0008

* Underline indicates significant difference (P <0.05).

Rejection rates for the 0.31 µm-HFATS comparisons are also listed in Table III. The combined HFATS rejection rates (HFATS only plus both) for all filters tested were $\leq$0.8% which is at the lower end of the range of rejection rates observed under routine conditions at the FTFs. The corresponding combined Q107 rates were lower than the HFATS rates.

TABLE III

PENETRATION REJECTIONS FOR THE 0.31 µm-HFATS COMPARISON

		FAILING 100% TESTS						FAILING 20% TESTS					
		HFATS ONLY		Q107 ONLY		BOTH		HFATS ONLY		Q107 ONLY		BOTH	
FILTER SIZE	NUMBER TESTED	NO.	%	NO.	%	NO.	%	NO.	%	NO.	%	NO.	%
4A	21	0	0	0	0	0	0	0	0	0	0	0	0
5	737	0	0	0	0	0	0	1	0.1	1	0.1	5	0.7
5A	39	0	0	0	0	0	0	0	0	0	0	0	0
6	52	1	1.9	0	0	2	3.9	1	1.9	0	0	0	0
TOTAL	849	1	0.1	0	0	2	0.2	2	0.2	1	0.1	5	0.6

Penetration Comparison with the 0.15 µm HFATS Data

Another important comparison that demonstrates the capability of the HFATS, is a comparison of HFATS measurements at the maximum penetration bin with the Q107 measurements. To determine if the bin in which the maximum penetration occurs is dependent upon the magnitude of maximum penetration, the maximum penetration bin was plotted against maximum penetration for the 100% and the 20% tests (Figures 6 and 7, respectively). Figure 6 shows that the maximum penetration occurs in the bin diameter range from approximately 0.1 µm to approximately 0.2 µm over the entire range of maximum penetration. No maximum penetration measurement occurred in a bin larger than the 0.21 µm bin. This relation between bin diameter and maximum penetration was independent of penetration. These conclusions are consistent with the shape of the 100% flow penetration curve found in Figure 3 which shows a distinct particle size of maximum penetration.

The 20% flow test results presented in Figure 7 show no such grouping of maximum penetration into a narrow bin diameter range. The data in Figure 7 appear to be evenly distributed over the entire range of bin diameters. This finding is also consistent with the shape of the 20% flow penetration curve found in Figure 3 which showed penetration to be independent of aerosol size.

The 100% flow data were used to plot the distribution of maximum penetration aerosol size (see Figure 8). For each of the filter

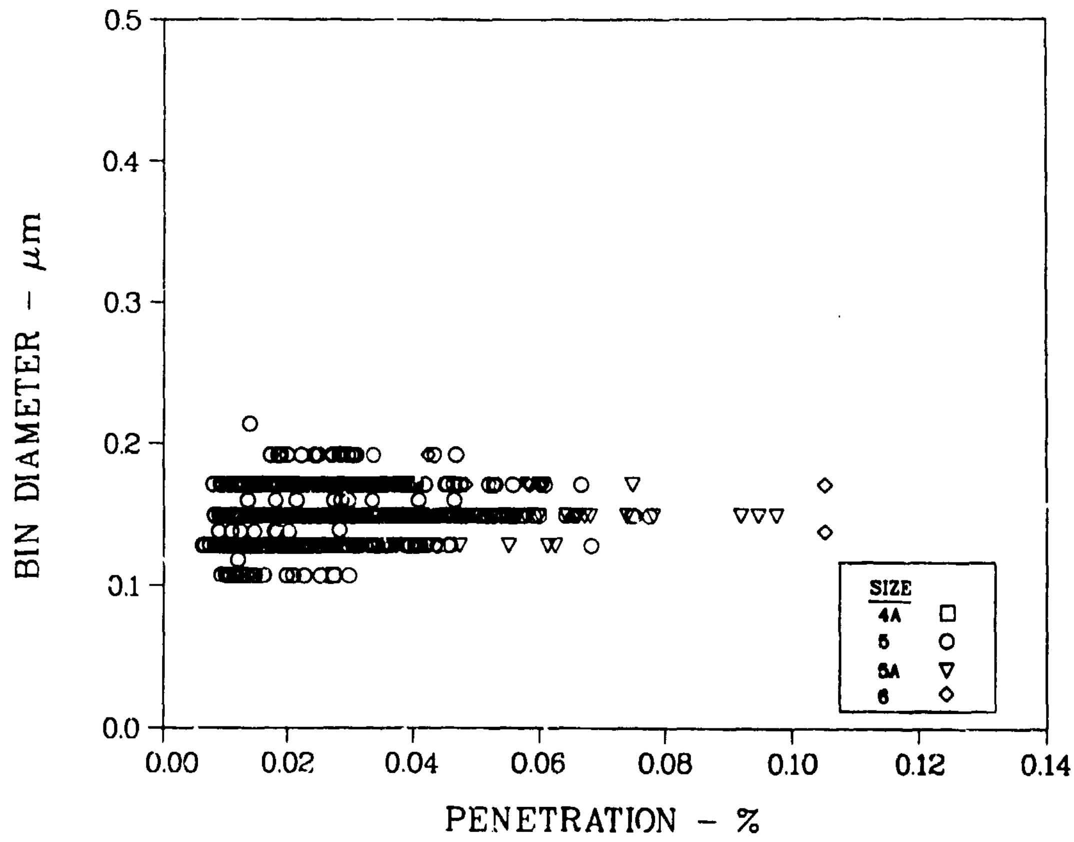

Figure 6. Plot of the maximum penetration bin diameter versus the maximum penetration for the 100% flow test data showing the grouping of the data in the bin diameter range from 0.1 µm to 0.2 µm.

sizes studied and for the total filter population, the maximum penetration was most frequently found in the 0.15 µm diameter bin. This corresponds to an electrostatic classifier measured diameter of approximately 0.17 µm. Table IV lists the number and percentage of filter tests that occurred in the various bins. For each of the filter sizes and for the total filter population, over 90% of the maximum penetration measurements occurred in the 0.13 µm to 0.17 µm bin diameter range. This range corresponds to an electrostatic classifier diameter range from approximately 0.14 µm to approximately 0.18 µm. No maximum penetration analysis of the 20% flow data was performed because those penetration data were found to be largely independent of aerosol size.

Results of the comparisons of the 0.15 µm HFATS data with the Q107 penetration data are shown in Figures 9 and 10. For the 100% flow data (see Figure 9), in almost every case the HFATS measurements are greater than the Q107 measurements. The results of the 20% flow comparison shown in Figure 10 are similar to the results of the 0.31 µm-HFATS comparison (see Figure 5) in which little difference was

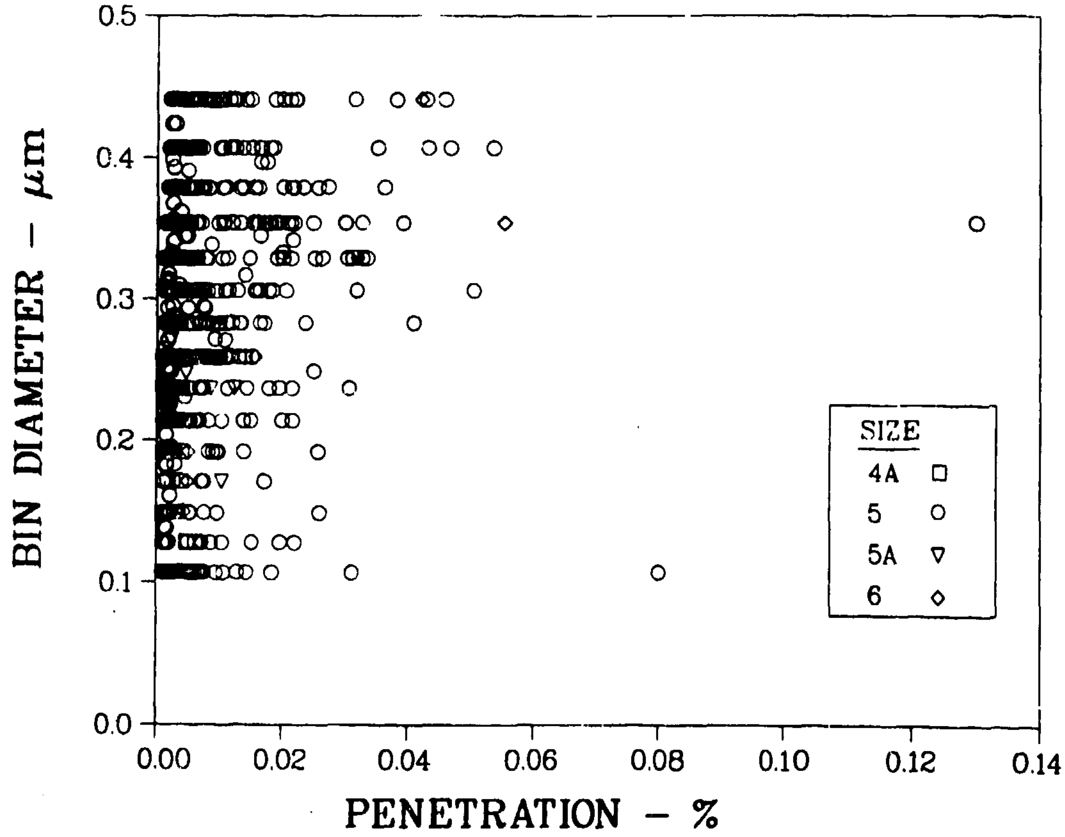

Figure 7. Plot of the maximum penetration bin diameter versus the maximum penetration for the 20% flow test data. No grouping of the data in a narrow bin diameter range was observed.

observed between the HFATS measurements and the Q107 measurements. Average-differences in penetration are listed in Table V. The average differences for the 100% flow tests ranged from 0.012% to 0.025% which are much greater than the corresponding differences observed in the 0.31 μm comparison. For the 20% flow tests the average differences were <0.002% which is similar to the differences observed in the corresponding tests in the 0.31 μm comparison.

The number of filter tests where penetration measurements were above the penetration rejection limit are listed in Table VI. A total of five filter tests resulted in both systems measuring penetrations above the rejection limit. For the 100% flow tests, the HFATS measured penetrations above the rejection limit in 156 situations where the Q107 measured penetrations were below the limit. For this same set of tests, the Q107 rejected no filters that were accepted by the HFATS. The number of filters that were rejected by the two systems in the 20% tests was similar to the number of filters rejected in the corresponding tests of the 0.31 μm comparison (see Table III).

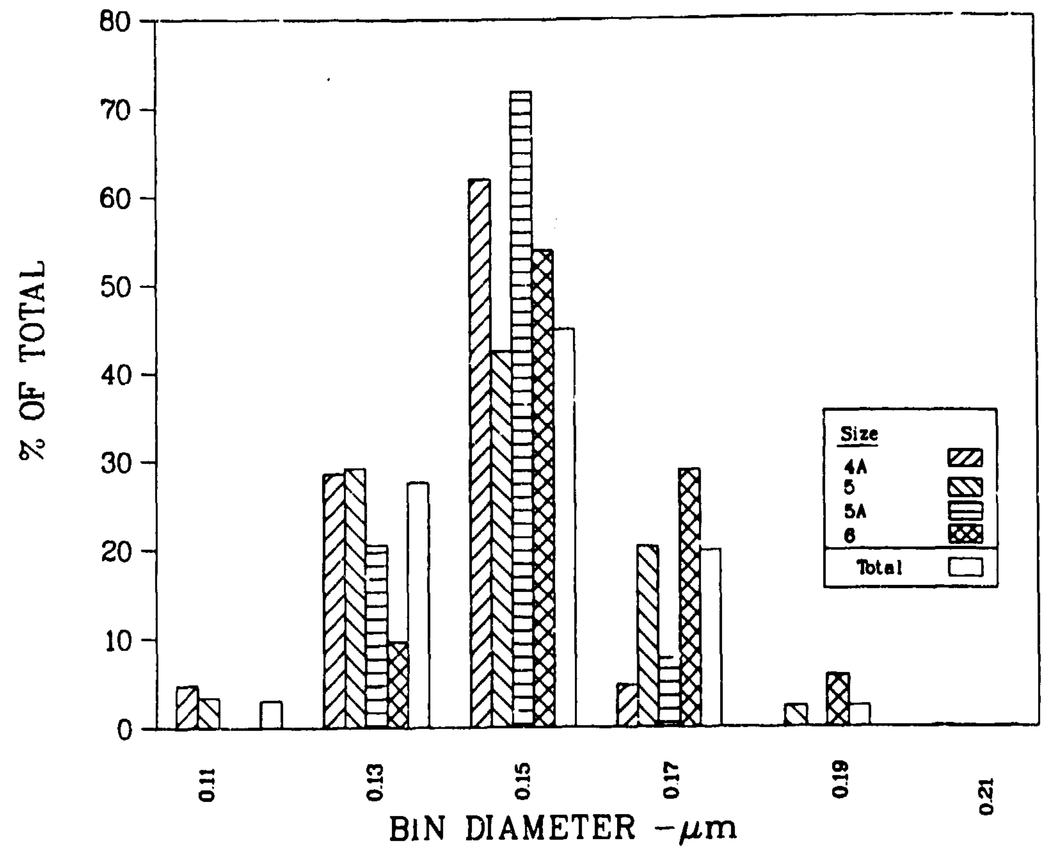

Figure 8. A discrete frequency plot of the bin diameters that contain the maximum penetration for all the filter sizes tested.

TABLE IV

AEROSOL SIZE OF MAXIMUM PENETRATION

	FILTER SIZE									
	4A		5		5A		6		TOTAL*	
BIN-um	NO.	%	NO.	%	NO.	%	NO.	%	NO.	%
0.11	1	4.8	25	3.4	0	0	0	0	26	3.1
0.13	6	29	21.5	29	8	21	5	10	234	28
0.15	13	62	312	42	28	72	28	54	318	45
0.17	1	4.8	149	20	3	7.7	15	29	168	20
0.19	0	0	17	2.3	0	0	3	5.8	20	2.4
0.21	0	0	1	0.1	0	0	0	0	1	0.1

* Filters with maximum in two or more bins were not included; therefore, this column adds to 830 rather than 849.

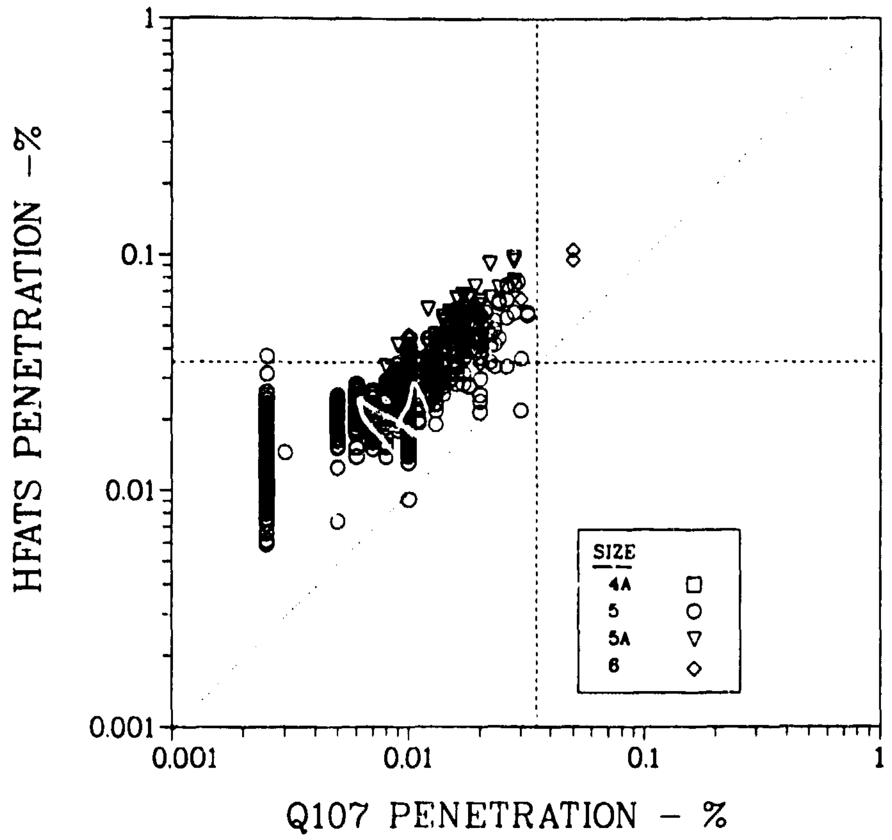

Figure 9. Comparison of the 100% flow test penetration measurements using the 0.15 µm HFATS data.

Rejection rates for the 0.15 µm-HFATS comparison are also listed in Table VI. The 100% flow "HFATS only" rejection rate for all filters tested was 18% which is much greater than the rejection rates observed under routine conditions at the FTFs. Over 50% of the size 5A and the size 6 filters were rejected by the HFATS in the 100% flow test. Thirteen per cent of the size 5 filters were rejected by the HFATS in this test. The remainder of the rejection rates listed in Table VI are at the lower end of the range of rejection rates observed at the FTF under routine conditions.

HFATS PERFORMANCE EVALUATION

Diluter Evaluation

A detailed calibration check of the HFATS diluter was performed at the beginning of the study (August 1985), once in the middle of the study (February 1986) and at the end of the study (May 1986). A plot of the dilution ratios measured during these three calibration sessions is shown in Figure 11. The dilution ratios at a given aerosol size were within 10% of one another. This indicates that the diluter calibration was stable during the 9-month study period.

LAS Size Calibration Evaluation

Prior to each HFATS test session the size calibration of the LAS was checked using a 0.22 µm manufacturer's diameter polystyrene

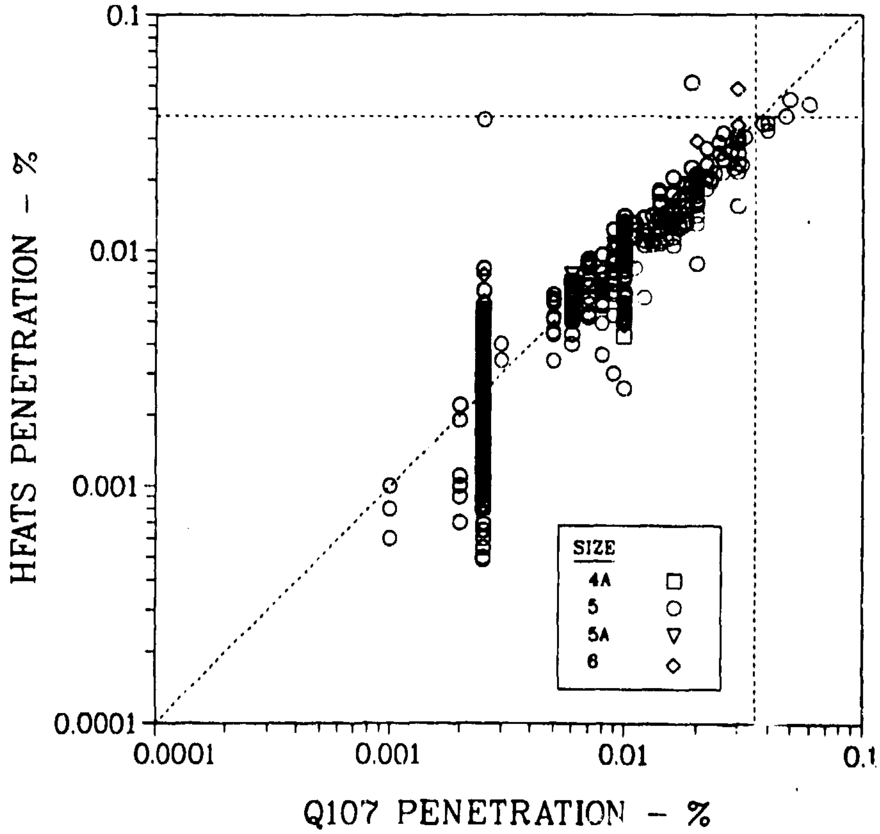

Figure 10. Comparison of the 20% flow test penetration measurements using the 0.15 µm HFATS data.

TABLE V

PENETRATION DIFFERENCES -- 0.15 µm
(HFATS - Q107)

FILTER SIZE	AVERAGE DIFFERENCE 100% FLOW	AVERAGE DIFFERENCE 20% FLOW
4A	0.017*	-0.0002
5	0.015	-0.0009
5A	0.012	-0.0002
6	0.025	0.0005

* Underline indicated significant differences (P <0.05).

microsphere suspension (PMS). The results of these calibration checks throughout the study are presented in Figure 12. Because the LAS is calibrated by the manufacturer with polystyrene microspheres no index of refraction correction was required for the calibration checks. The calibration of the LAS was within one bin of the manufacturer's diameter in all but one calibration check. A cleaning of the critical LAS optics in February 1986 shifted the LAS calibration from a diameter of 0.2 µm back to the PMS manufacturer's diameter. The 0.18 µm diameter calibration check in early May 1986, is suspected to be the result a steam excursion during a repair of the Q107 that dirtied the LAS optics. In this situation, the LAS reference voltage was below the manufacturer's recommended limit for operation. Again, cleaning of the critical optics by FTF personnel restored the calibration.

Upstream Count Rate Evaluation

After the upstream count of every filter test the upstream count rate measured by the LAS was automatically recorded and printed by the HP-85 microcomputer. As described earlier, this provides the operator with a continuing frequent indication on how well the HFATS is performing. Changes in the output of the blower or the HFATS generator or changes in the performance of the HFATS diluter or the LAS would affect this count rate. A plot of the measured count rates over the term of the study is shown in Figure 13. The plot shows no trend upwards or downwards over the term of the study. In general, the occasional single measurement changes in count rate were found to be associated with blower adjustments to accommodate the operation of the Q107. The count rate returned to its normal magnitude (between approximately 1400 and 1600 counts/sec) when the blower output was adjusted back to its standard level. The one sustained drop in count rate that occurred in early January 1986 was the result of the operator leaving the blower in the high output position after a Q107 test series. These data indicate that the performance of the HFATS equipment was stable during the 9-month study. Examination of the data during individual test sessions shows no distinct general increase or decrease in the upstream count rate.

TABLE VI

PENETRATION REJECTIONS FOR THE 0.15 µm-HFATS COMPARISON

		FAILING 100% TESTS						FAILING 20% TESTS					
		HFATS ONLY		Q107 ONLY		BOTH		HFATS ONLY		Q107 ONLY		BOTH	
FILTER SIZE	NUMBER TESTED	NO.	%	NO.	%	NO.	%	NO.	%	NO.	%	NO.	%
4A	21	0	0	0	0	0	0	0	0	0	0	0	0
5	737	95	13	0	0	0	0	2	0.3	3	0.4	3	0.4
5A	39	34	87	0	0	0	0	0	0	0	0	0	0
6	52	27	52	0	0	2	3.9	1	1.9	0	0	0	0
TOTAL	849	156	18	0	0	2	0.2	3	0.4	3	0.4	3	0.4

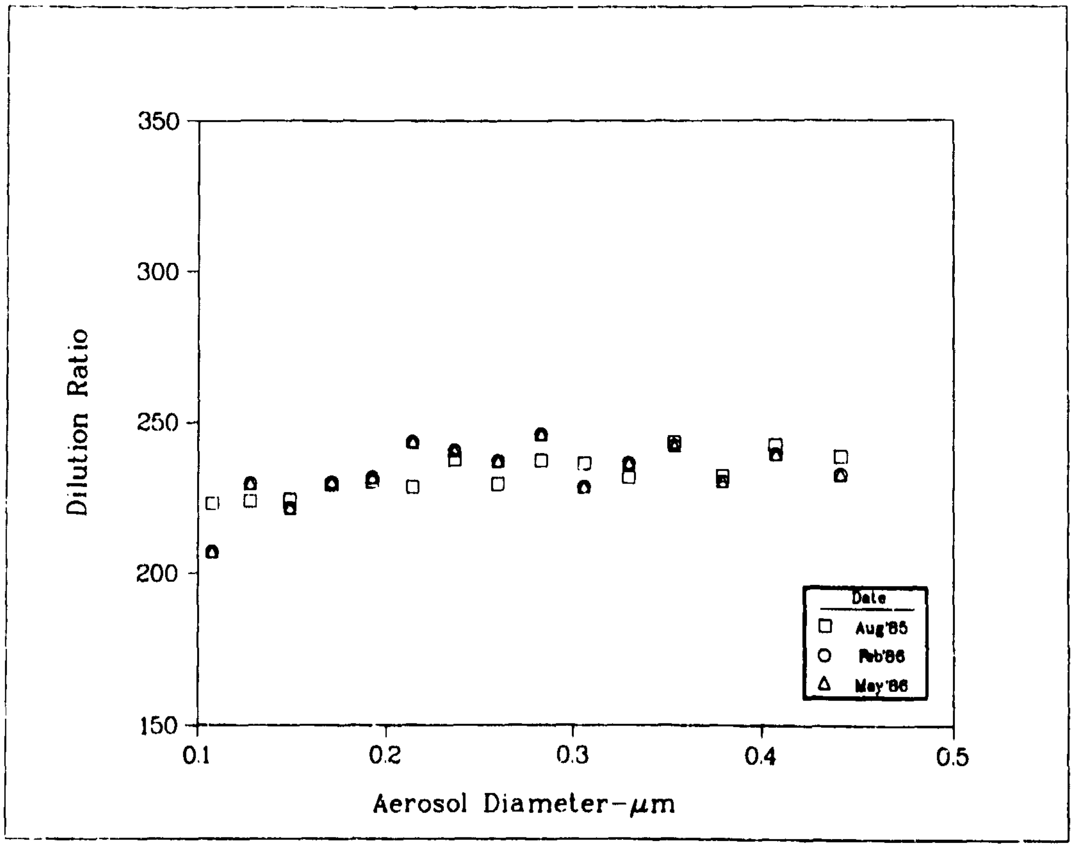

Figure 11. Comparison of three diluter calibration evaluations performed over the course of the study.

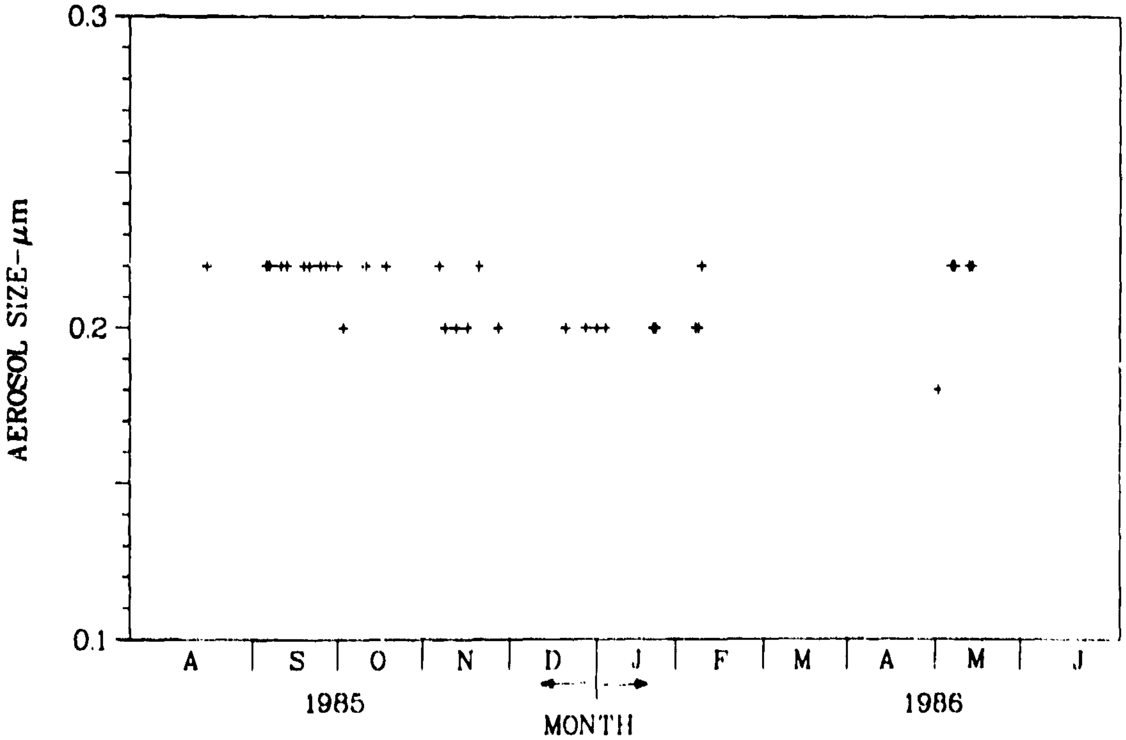

Figure 12. Results of the LAS calibration checks performed throughout the study.

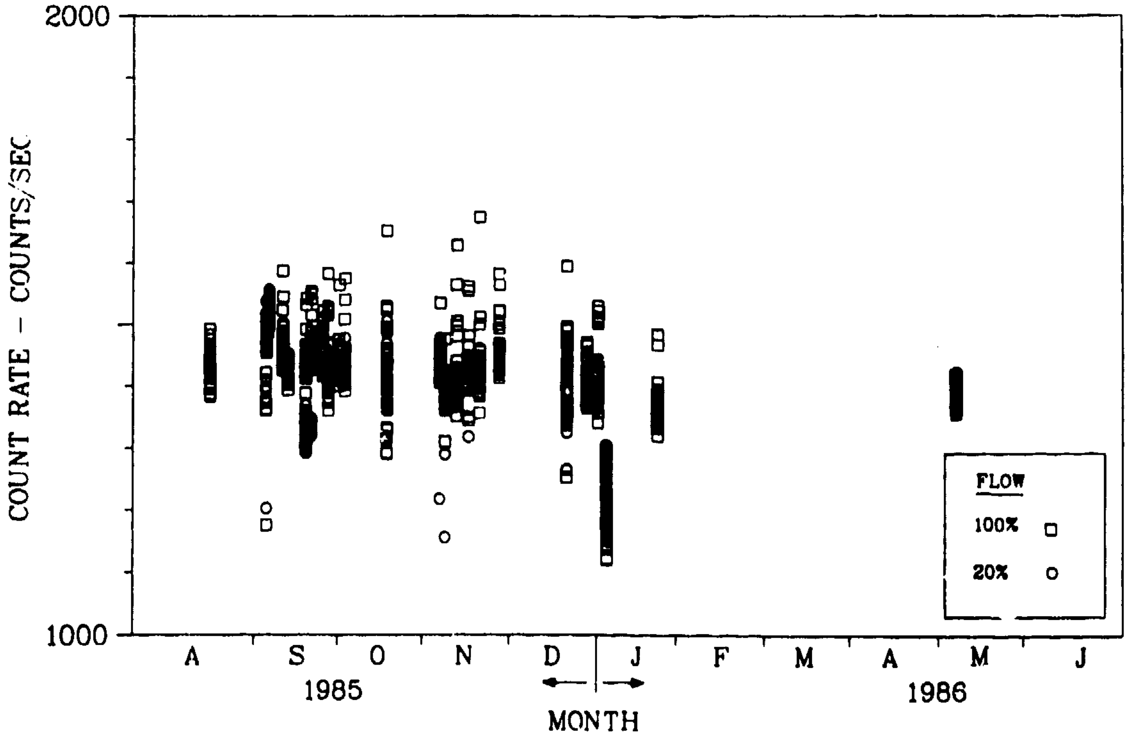

Figure 13. Results of the upstream count rate evaluation performed throughout the study.

HFATS IMPACTS ON FTF OPERATION

Comparison of Filter Test Rates

Records of the time required to test a filter set were kept by the Oak Ridge test system operator. The time recorded by the operator included the test system start-up time as well as the time required to test the set of filters. The time required to shutdown the test systems was not included in the recorded time because the time of day that testing had to cease was largely determined by the amount of time at the end of the work day that had to be allocated to storing the tested filters and recording filter test results.

The rate at which filters were tested was calculated by dividing the recorded time into the number of filters tested. A plot of these rates over the term of the study is shown in Figure 14. The HFATS test rates in the initial weeks of the study increased from a low of approximately 5 filters/hr to a rate of almost 6.5 filters/hr. This increase is probably related to the operator becoming familiar with the study and HFATS operating procedures. The HFATS rates measured from the beginning of October 1985 through the end of the study were constant, save one case, at a rate just below 6.5 filters/hr. The Q107 rates showed some fluctuation early in the study, but again by about the beginning of October 1985 the rates became constant, save two cases, at a rate of just below 7.5 filters/hr. The high rates (>7.5 filters/hr) observed in January 1986 were found to be associated with filter test sessions that were conducted after a

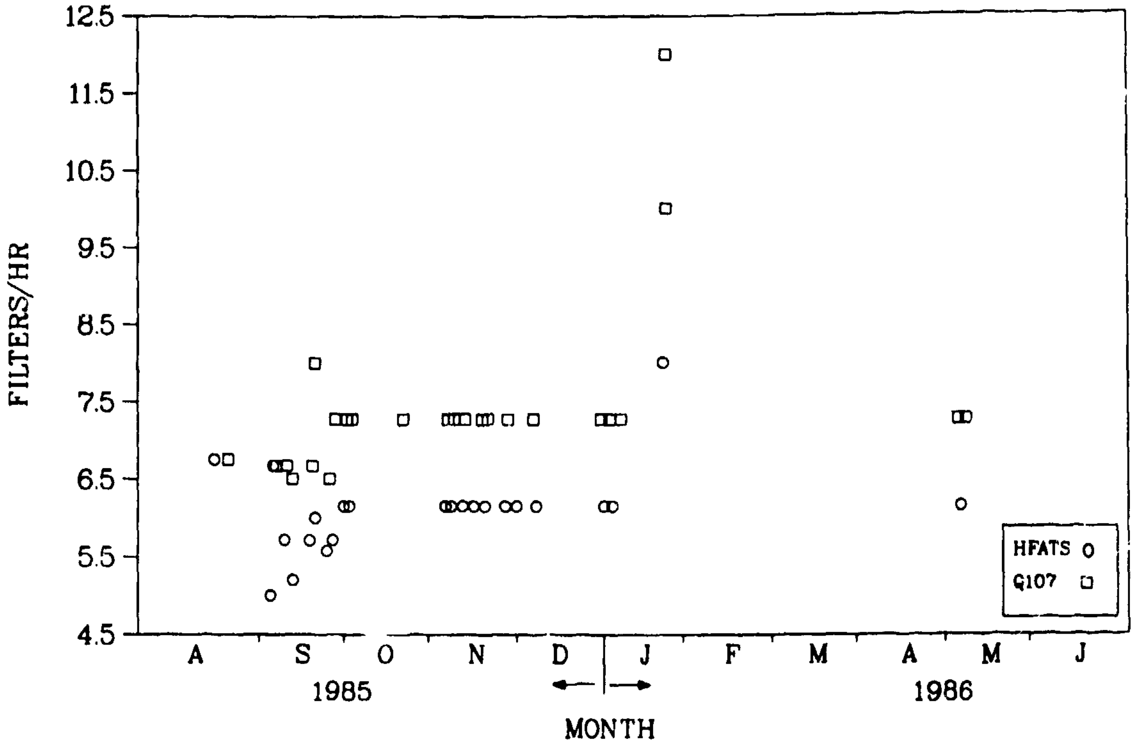

Figure 14. A plot of the filter test rates for the HFATS and the Q107 over the term of the study.

previous test session for which the test systems had been started. Consequently, no start-up time was included in the high rate session's recorded time.

Even though the rate at which the Q107 test filters is distinctly greater than the HFATS test rate, there was no difference in the number of filters that could be tested by either system in a work day. This conclusion comes from the fact that the number of filters that can be tested in a day at the CRFTF is largely dependent on the logistics of conveying filters to and from the location where they are tested and the Q107 cool down time. Filters are conveyed to and from the test location by a batch process in which a set of filters is unpacked, placed on a conveyor, and moved to the test location. After testing, they must be conveyed back to the store room and stored prior to loading the next set of filters for testing. Testing of two batches of up to 24 filters with the Q107 required enough of the work day that with the time required prior to the end of the work day for attending the Q107 during its cool down (approximately a half hour) there was no more time to load and begin testing another set of filters. The same two batches of filters can be tested by the HFATS in a day because the shorter time required to shutdown the HFATS (<5 min) allowed enough extra testing time to make up for the slower rate at which the HFATS tested filters. Operationally, the main difference in a day of testing with the two systems is that the operator spends more time testing filters with the HFATS and is not available to carry out other duties that the individual might be able to do while attending to the Q107 during its cool down phase.

Certain possibilities exist for increasing the HFATS filter test rate. First, the series of calibration checks and the extensive data collection that were conducted in the operational evaluation may not be necessary for routine FTF operation of the HFATS. The high degree of stability displayed by the HFATS supports extending the time between calibration checks. A significant amount of time was required to automatically store the large amount of data retained for each filter test. This time could be significantly reduced by using a faster data storage system and by limiting the amount of data stored. Another way of reducing the time required to test filters would be to reduce the clearing time between the upstream and downstream counts and between the 100% flow test and the 20% test. A valve design that would permit reduction of the required clearance time is being investigated.

These recommendations have the potential of increasing the HFATS test rate to approximately that of the Q107. However, it is unlikely that the HFATS test rate could be increased to a rate much higher than the Q107 rate because of the 4 to 5 minutes required by the HFATS to make the necessary count measurements for a filter test.

HFATS Operational Safety

A major advantage that was attributed by the Oak Ridge staff to the HFATS was that the DEHP odor present when operating the Q107 was not present during the operation of the HFATS. In addition, a former Oak Ridge test system operator who had stopped testing filters because of sensitivity to DEHP odors, was able to test filters with the HFATS. The Department of Energy has adopted the policy of limiting workplace exposures to filter test material through the use of engineering controls.[1] The challenge aerosol concentration used in the HFATS is at least an order of magnitude lower than the Q107 challenge concentration, which means the source term for emissions to the workplace is greatly reduced for the HFATS relative to the Q107. The reduced source term is probably at least partially responsible for the absence of odor associated with the HFATS operation. Reduction of the source term represents an appropriate engineering control for limiting workplace exposures.

Another major operational safety issue is the potential fire hazard the Q107 thermal generator presents. Because of the possibility of fire, Q107 systems are fitted with costly fire suppression equipment. None of the HFATS components present a safety problem of this magnitude. The HFATS generator uses air-operated jets to produce the challenge aerosol. This method of aerosol production greatly reduces the risk of fire.

Operation of the HFATS

The Oak Ridge staff gained several insights into the operation of the HFATS in the FTF environment relative to the operation of the Q107. A major difference in the systems was the relative amounts of operator attention that they required. Because the Q107 uses a thermal generator that heats the test aerosol material to near its flash, once the system is started, it must be attended to until approximately a half hour after the cool down phase is initiated in order to assure that temperature excursions are thwarted.

During actual operation of the test systems the HFATS required much less attention and adjustments than did the Q107. Most of the attention and adjustments required by the Q107 was associated with maintaining the challenge aerosol particle size and concentration. The challenge aerosol particle size requirements for the HFATS are less stringent than those for the Q107 because the HFATS particle size discrimination is performed by the LAS. The output of the HFATS generator and the performance of the HFATS diluter and the LAS as indicated by the performance indicators was so stable that close monitoring by the operator was not needed. The HFATS required almost no adjustment during the study.

Maintenance of the HFATS

Direct comparison of the maintenance time required by the test systems is not completely appropriate because of the differing ages of the system's components. The HFATS system components, however, were not all new. For example, the LAS used in the study was over 7 years old and used a laser tube that at the beginning of the study was more than 1 year old. The HFATS required less than 2 hours maintenance during the 9-month operational evaluation, which was associated with cleaning the critical optics of the LAS. The Q107 aerosol generation system required more than 2 days maintenance. Maintenance of the large capacity equipment used to condition high flow air streams of the Q107 generating system to within very close tolerances has been a recurring problem at Oak Ridge. Repair of these conditioning systems has required significant periods of down time and has been costly.

A concern with the HFATS is the availability of repairs and replacement parts for the LAS. A possible remedy to this potential problem is to contract with the LAS manufacturer to maintain a LAS that would be ready to be shipped to a FTF in the event a replacement was needed. The time between maintenance periods for the LAS should be increased according to the LAS manufacturer because the useful life of the laser tubes has been extended from 1 year to 5 years by the use of a new glass to metal sealing process. The tube in the LAS used in the study has lasted over 2 years to-date.

IV. Summary

The comparison of 0.31 µm HFATS penetration measurements and rejection rates to those of the Q107 indicated that there was not much difference in the magnitude of the measurements. This indicated that operation of the HFATS in this mode would not greatly affect the measurements reported by the FTFs. On the other hand the 0.15 µm HFATS measurements made at the 100% test flow were distinctly greater than the corresponding Q107 measurements. The HFATS provides the capability of measuring worst case filter penetration and readily determining penetration in terms of physical factors of concern (i.e. mass, radioactivity, etc.).

The HFATS demonstrated excellent stability as indicated by the diluter evaluation results, the LAS size calibration results and the upstream count rate results. These data suggest that an extended calibration check schedule would be appropriate for the HFATS.

The major negative impact that the HFATS appears to have on the FTF operation is the lower rate at which filters are tested. However, there was no difference in the number of filters that could be tested by either system in a day. The HFATS exhibited certain positive effects on the FTF operation. These included potential reduction in the workplace airborne levels of the test aerosol material, limiting the fire hazard associated with testing filters, easier operation and potentially less costly and less frequent maintenance.

V. Conclusion

The results of this study demonstrate the operability and maintainability of the HFATS in the FTF environment. The operational advantages cited above and the technical advantages cited elsewhere demonstrate that the use of the HFATS at the FTFs would improve the FTF operation and improve the technical defensibility of the FTF penetration measurements.[2] Because of this conclusion, the authors recommend that the Department of Energy consider adoption of the HFATS as an approved filter test system under the provisions of the NE-F-3-43.[1]

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